Title: Improving Store Separation Six-Degree-of-Freedom Tools (ISSSDF)

Investigator:

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Background: The Air Force uses the TGP program as its primary tool for predicting store trajectories on the basis of wind tunnel grid data. The US Navy uses NAVSEP, which is based on an earlier version of the TGP code. Both codes are based on the AEDC Multi-Dimensional Interpolation Trajectory Generation Program, and have undergone numerous improvement/modifications during the past 15 years. The U.S. Navy and Air Force have also recently acquired Store Trajectory Estimation in a MATLAB Environment (STEME) code from the Australian Air Force.

NAVAIR is in the process of preparing a flight clearance for the High Speed Anti-radiation Demonstrator (HSAD) program. This clearance will be prepared using the conventional tool NAVSEP. The HSAD missile, however, utilizes an autopilot to move four movable control fins shortly after release as it rapidly accelerates in flight speed. It would be highly desirable to fully account for these elements in the release simulation using either NAVSEP, TGP, or STEME.

NAVSEP, TGP have amassed a long lineage of wind tunnel data, flight simulation predictions, and flight test data with which to perform code validation and verification. Therefore, new developments should preserve as much backward compatibility as possible with existing TGP codes while improving and developing user interfaces and increasing functionality. In conjunction with the conventional NAVSEP approach to clear the HSAD missile, it would be desirable to test the TGP and STEME codes for the same case.

It would be desirable to develop the general methodology to integrate the current 6 DOF analysis approaches with the proposed MATLAB/Simulink auto-pilot environment. The Navy is currently involved in developing the joint-service Joint Common Missile with Lockheed. Both FLIP TGP and NAVSEP codes coupled with MATLAB/Simulink will be tested for this particular missile. Recently, a Beggar approach with hard-coded auto-pilot has been practiced. However, a loosely coupled Beggar approach with MATLAB/Simulink seems to be more flexible to allow users to have more options on auto-pilot parameters. This CFD approach will be also applied to see a feasibility to develop the general auto-pilot integration methodology.

Objective: This project will support the IHAAA Strategic Goals through the accomplishment of the following project specific contributions:

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The ISSSDF project will contribute to an application of best practice for the separation of stores with autopilot simulations. This is a current real-world problem that can benefit from the optimal utilization of HPC technology combined with existing six-degree of freedom codes.

The ISSSDF project will have an immediate impact on HSAD analysis that will be indicated by the case load to support future missile autopilot simulations. It will help support current F-18C/D/HSAD flight testing and future testing of weapons with autopilots from any delivery platform.

Cost avoidance is expected through optimization or avoidance of flight testing that leads to airworthiness certification of F-18C/D /HSAD configurations. The value of this cost avoidance will be included in the total cost avoidance metric for FY06.

IHAAA HPC tool endorsement will be accomplished on a case-by-case basis. The ISSSDF project will contribute to IHAAA tool endorsement for the case of separation of weapons with active autopilots. Optimal application of HPC tools will be accomplished by HPC AI experts and critical review of the HPC derived data will be accomplished by the CA expert in using such data to make critical engineering decisions and is the final authority for flight certification of new weapon load-out configurations on Navy weapons platforms.

After validating the ISSSDF tool for the HSAD flight test, workshops will be conducted at AEDC and AFSEO, so that those organizations can modify their TGP code to employ the new capabilities.

The ISSSDF project is a collaborative effort with joint participation by Navy, AEDC and Air Force. The ISSSDF Project Team will work together to identify opportunities for technology transfer, review/approve best practices, document technology shortfalls, and remediate process shortfalls.

The project goals are to demonstrate and validate simulation of missile autopilots using current AEDC, Air Force and Navy six-degree-of-freedom codes. This includes measuring the timeliness and accuracy of collaborator's local capabilities. This program will determine an optimum approach using these methods.

The specific configuration chosen is the F/A-18C/D aircraft with a HSAD missile on station 3. A 330-gallon external fuel tank is located on Station 3. Title: Parametric Analysis of the Store Separation of a High Speed Anti-Radiation Demonstrator (HSAD) Missile

Method and Results:

Several store separation trajectory simulation tools (including NAVSEP and AEDC TGP) were used with Wind Tunnel test data to clear HSAD for a its first free flight test from

the F/A-18C parent aircraft at a Mach number of 0.8 and a pressure altitude of 30,000 feet. Comparative analysis between the tools revealed a deficiency in the TGP based codes when predicting the trajectory of stores with off centerline axis thrust. A method was devised to incorporate autopilot functionality, and to Mach interpolate freestream wind tunnel data in NAVSEP simulations using MATLAB/SIMULINK. A parametric analysis of the release was conducted to account for uncertainty in the freestream, grid, and control surface effectiveness wind tunnel data, in uncertainty in the mass properties, and uncertainty in the thrust profile with and without the autopilot engaged.

The High Speed Anti-radiation Demonstrator (HSAD) Program intends to demonstrate key enabling technologies for inclusion in the follow-on to the AGM-88E HARM missile during one captive carry and two free-flight tests. The HSAD missile is planned for release from an F/A-18C/D aircraft at a Mach number of 0.8 and an altitude of 30,000 feet. Recent improvements to the U.S. Navy's store separation prediction code (NAVSEP) have allowed the U.S. Navy to analyze the separation of the missile and include the effects of the autopilot and moving control surfaces modeled in MATLAB/SIMULINK.

Publications and Presentations:

Title: Parametric Analysis of the Store Separation of a High Speed Anti-Radiation Demonstrator (HSAD) Missile. Paper presented at the AIAA Atmospherics and Flight Mechanics Conference and Exhibit, Keystone, CO, 21 - 24 AUG 2006.

Title: MATLAB Based Telemetry Integration Utility for Store Separation Analysis. Papers presented at the AIAA Air Force T&E Days, Destin, FL, 13 – 15 FEB 2007.

Title: IHAAA Applications to Reducing Store Separation Flight Testing. Paper presented at the AIAA Air Force T&E Days, Destin, FL, 13 – 15 FEB 2007.

Seminar: IHAAA Workshop
Title: Requirements for Autopilot Functionality in Store Separation Simulations
Date: 30 APR - 1 MAY 2007
Venue: University of Florida Graduate Engineering Research Center

Seminar: NAVAIR Air Vehicle Engineering Conference
Title: Lessons Learned in Near-real Time Processing of Store Separation Telemetry Data
Date: 6 JUN 2007
Venue: NAVAIR Engineering Conference